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RESEARCH MEMORANDUM

ANALYSIS OF V-g DATA OBTAINED FROM SEVERAL NAVAL AIRPLANES

By James O. Thornton

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

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ANALYSIS OF V-g DATA OBTAINED FROM SEVERAL NAVAL AIRPLANES

By James O. Thornton

SUMMARY

Composite envelopes of V-g records obtained in training and operational flights with the F8F-1, SB2C-5, F6F-5, F4U-4, and TBM-3 airplanes are given and compared with the design envelopes. In addition, the records from the F8F-1, SB2C-5, and F6F-5 airplanes are analyzed statistically to show a variation of large values of acceleration and airspeed with time.

INTRODUCTION

The loads encountered in flight must be known before an efficient airplane design is possible. For maneuverable airplanes, these loads vary with the aerodynamic characteristics and type of operation. Since V-g data can furnish the experience of previous airplanes on similar missions, the possibility is suggested that flight loads may be predicted from the analysis of such records. Work of this nature has been carried on for the last few years in this country and abroad, a recent example of which is given in reference 1.

V-g records supplied the NACA by the Bureau of Aeronautics in 1948 and 1949 have provided additional material. These records are analyzed statistically in this report to show the frequency of large values of acceleration and airspeed, and results are compared with the design requirements.

SYMBOLS

Δn_{max}	maximum positive or negative acceleration increment on V-g record, g units
V_o	indicated airspeed at which maximum positive or negative acceleration increment on V-g record is experienced, miles per hour
V_{max}	maximum indicated airspeed on V-g record, miles per hour
σ	standard deviation of frequency distribution, reference 2
Δn_v	acceleration increment corresponding to V_{max}, g units
$\overline{V}_{max}$, $\overline{\Delta n}_{max}$, $\overline{V}_o$	average values of frequency distributions of V_{max}, Δn_{max}, and V_o, respectively
$\Sigma P_{\Delta n}$	probability that maximum acceleration increment on V-g record will exceed a given value
$P_{\Delta n}$	probability that value of maximum acceleration increment on V-g record will occur in a given interval
ΣP_v	probability that maximum indicated airspeed on V-g record will exceed a given value
P_v	probability that value of maximum indicated airspeed on V-g record will occur in a given interval
T	total flight time, hours
τ	average flight time per record, hours
α_3	coefficient of skewness of frequency distribution, reference 2
α_4	coefficient of kurtosis of frequency distribution, reference 2
MID-X	midpoint of class interval of frequency distribution
k	number of classes in frequency distribution

SCOPE OF DATA

The data available for analysis consisted of V-g records obtained with the F8F-1, F6F-5, F4U-4, SBC2C-5, and TBM-3 airplanes. The F8F-1, F6F-5, and F4U-4 airplanes are single-place fighters; the SB2C-5 is a two-place, low-midwing dive bomber; and the TBM-3 airplane is a three-place, midwing torpedo bomber. All airplanes are single engine and are carrier-based types. A few pertinent details are listed in the following table:

Airplane	Gross weight (lb)	Average take-off weight (lb)	Stick-force requirements, lb/g (reference 3)	
			Minimum	Maximum
F8F-1	9400	9350		
F6F-5	12500	12300	3	$8\frac{1}{2}$
F4U-4	12500	11600		
TBM-3	15500	14500	7	28
SB2C-5	15550	14200	3	13

Sufficient records were available on the F8F-1, SB2C-5, and F6F-5 airplanes to make a statistical analysis. The distribution of flying hours on these records is shown in figure 1 where the flying time per record is plotted against number of records. In addition to the data of figure 1, 35 records were furnished on the F4U-4 airplane and 45 records on the TBM-3 airplane.

Postwar fleet squadron operations of Attack Carrier Air Group 11 provided a common source of records obtained with the F8F-1, SB2C-5, F6F-5, and TBM-3 airplanes. Operations carried out by each airplane were as follows: F8F-1, diving and dive pull-outs, gunnery runs, routine squadron operations; SB2C-5, dive bombing, gunnery runs, rocket runs, bombing and simulated attack; TBM-3, night operations and glide bombing; and F6F-5, bombing rocket runs and simulated attacks. Some SB2C-5 and F4U-4 records were obtained from the Naval Air Training Station at Jacksonville, Fla.

Wartime operations were limited to 76 records from the F6F-5 airplane and 8 records from the F4U-4 airplane obtained in the Pacific area in 1945. Operations carried out were as follows: F6F-5, combat air patrol, gunnery, and simulated combat; F4U-4, strafing enemy installations, gunnery practice, and simulated combat.

METHOD AND RESULTS

Composite diagrams, or overlays of the V-g records by airplane type, are given by the irregular solid lines in figures 2 to 6. Since it was not possible to determine the airplane weight at which these accelerations occurred, the assumption was made that they apply to an average weight at take-off. The dashed-line limit-load-factor curves shown in these figures were based on this assumption.

Although further study of the V-g records from the F4U-4 and TBM-3 airplanes was prevented by limited data, an analysis of records from the F8F-1, SB2C-5, and F6F-5 airplanes was made to determine V-g "flight" envelopes and the frequency of large values of acceleration and airspeed. Figures 7 and 8 are sample V-g records showing the values which were read. For the SB2C-5 airplane, seven values were read from each record: these were the maximum positive acceleration increment Δn_{max} and the airspeed at which it occurred V_o; the maximum indicated airspeed V_{max} and the acceleration at which it occurred Δn_v; and the maximum negative acceleration increment Δn_{max} and the airspeed at which it occurred V_o; and the flying time represented by the record τ.

Records from the F8F-1 and F6F-5 airplanes differed from those of the SB2C-5 airplane in having two peaks of positive acceleration. The low-speed peak was caused by maneuvers started below the maximum level-flight speed of the airplane, while the high-speed peak was caused by diving to some excess of speed and pulling out of the dive. In order to treat these peaks separately, nine values were read, the last two being the maximum acceleration increment in high-speed flight and the airspeed at which it occurred.

Tables I to III show each value of acceleration and airspeed arranged in a frequency distribution. In order to smooth and extend these data to obtain the accelerations and airspeeds expected as flying time increases, Pearson type probability curves were chosen by the methods of reference 4. Essentially, this consists of computing the first four moments of the data about the mean and matching these moments with the moments of a Pearson frequency distribution. The parameters involved are the mean value, the standard deviation σ, and the statistical coefficients α_3 and α_4. These curves give the probability of exceeding a given value of acceleration or airspeed on a V-g record and are used in drawing V-g flight envelopes.

Details of the construction of the flight envelopes shown in figures 6 to 8 are discussed in references 5 and 6. These envelopes are composed of segments which will be exceeded, on the average, once in the stated number of hours with equal chance of being exceeded in any range of the segment. In figures 4 and 6, four segments are used to enclose the area: low-speed positive maneuvers, high-speed positive maneuvers, maximum airspeed, and negative accelerations. Each envelope is broken off on intersection with the curve of $C_{L_{max}}$.

The construction of an envelope segment of maximum airspeed is parallel to that of the other segments. In table IV, the occurrence of a maximum value of airspeed on a V-g record and the fact that the value occurs at a particular acceleration are considered to be independent events. As such, the probability P of a maximum value of airspeed occurring in a given interval of acceleration is the product of the separate probabilities and is equal to τ/kT as explained in reference 5. In symbols, this is

$$P = P_{\Delta n} \Sigma P_{v} = \frac{\tau}{kT}$$

where all values are available except ΣP_{v}. The corresponding V_{max} is found by reference to the probability distribution of V_{max}.

Figures 9 to 12 are probability curves transformed by multiplying the reciprocal of the probability by τ to give the average time required to exceed maximum values of airspeed and acceleration. In these figures the probability is that the given value will be exceeded once in the specified interval of time. The ordinates of these curves are the average numbers of flying hours in which an airplane will exceed the stated value once; or if large numbers of airplanes are considered, the ordinates become the sum of the flying hours of a group of airplanes in which, on the average, one airplane will exceed the stated value once. The design load factors in these figures are based on an average weight at take-off. Negative ultimate load factors were not included since they were not critical. Crude statistical tests show that in most cases the error due to sampling is less than 5 percent of the airspeed and 10 percent of the acceleration.

Figures 10 and 12 compare the loading obtained in low-speed maneuvers with that obtained in high-speed maneuvers. A more general curve giving the time to exceed a value of acceleration regardless of the maneuver in which it was obtained was found in the following manner: Since a maximum value of acceleration increment on a V-g record may occur in a high- or low-speed range (but not both), these events are exclusive, and the loads due to either were obtained by taking the sum of the separate probabilities. In terms of time, this is

$$T = \frac{T_1 T_2}{T_1 + T_2}$$

where the subscripts refer to high- and low-speed maneuvers, respectively.

The average ratio of airplanes which will exceed the design ultimate load factor to all airplanes flying is shown for given periods of time in figures 10 to 12. These ratios are fixed by T/h, where h is the average time to reach ultimate load factor, and are a result of the failure rate set by the choice of ultimate load factor. Losses are not exactly determined, of course, because finding h involves extending the original data to the ultimate load, and because airplanes may not fail at the design ultimate load.

Accelerations and load factors based on the normal gross weight are shown in figure 13 in order to compare the F8F-1, SB2C-5, and F6F-5 airplanes.

DISCUSSION

Since a V-g record obscures values of acceleration and airspeed that are not a maximum, a total count of these obscured values cannot be made. Figures 9 to 13 therefore give the average time in which maximum values on a V-g record are exceeded rather than a total frequency of exceeding given values. The difference is not significant for large values, and results given in these figures are said to apply to individual occurrences of the large values. The results, however, represent a set of operational conditions that only existed when the records were taken. The effect of small changes in these conditions has not been determined, but a gross change would, in all likelihood, give different results.

The application of statistical methods to maneuverable flight data is sometimes objected to on the grounds that maneuvers are arbitrary. The data in figures 9 to 13, however, show regular trends with time, indicating that while the intent of an individual maneuver may be arbitrary, the accelerations and airspeeds obtained in practice are random, and consequently respond to statistical treatment.

Since the events are random, the frequency of an event does not tell when it may occur. It is noted in figure 4 that the maximum values of the composite diagram exceed the predicted envelopes or any reasonable extension thereof. Figure 10, for example, indicates that the large acceleration in figure 4, which has occurred in some 5000 hours of flight, is only exceeded on the average every 20,000 hours. Apparently then, an airplane can obtain the largest loads in its early hours of flight. In this connection it is shown that the position of these events within a given period of time is not fixed; and that the event may occur first, last, or in the middle of a period of time, depending on the starting point from which time is measured. The thing that does not change is the average frequency which in this case is one event in 20,000 hours.

Although the average time in which limit load factor is exceeded has been used on occasion as a measure of the life of transport airplanes, the average time in which ultimate load is exceeded is a more appropriate measure for maneuverable airplanes. It is seen in figure 13 that a maneuverable airplane can exceed its limit load quite early without exceeding its design ultimate load in a reasonable time. For purposes of discussion, therefore, a figure which may be taken to compare the safety of maneuverable airplanes is the average time in which the design ultimate load is exceeded. On this basis, figures 10 to 12 indicate that the F8F-1 and SB2C-5 airplanes have practically identical service lives while the F6F-5 airplane has a shorter service life by a factor of approximately 50.

Ordinarily the loading experienced by a maneuverable airplane would be expected to depend on its maneuverability as measured by stick force per g. However, other factors beside stick force per g are evidently important. This fact is indicated by the F8F-1 and F6F-5 airplanes which obtain accelerations and airspeeds with different frequencies, although they have about the same stick force per g.

CONCLUDING REMARKS

The analysis of V-g data obtained in maneuvers indicates that large values of acceleration and airspeed are random and can be subjected to a statistical analysis. Since the limit load factors of maneuverable airplanes are exceeded in a relatively short period of time, the design ultimate load factor is a more appropriate level on which to base the safety of maneuverable airplanes than the limit load factor. It appears from the data that other factors beside stick force per g have an important bearing on the accelerations that are experienced.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

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TABLE I

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM F8F-1 RECORDS

Positive accelerations in level flight				Positive accelerations in dive pull-outs			
Δn_{max} (g)	Frequency	V_o (mph)	Frequency	Δn_{max} (g)	Frequency	V_o (mph)	Frequency
1.0 – 1.4	2	195 – 209	1	0.8 – 1.1	4	325 – 334	3
1.5 – 1.9	5	210 – 224	3	1.2 – 1.5	1	335 – 344	0
2.0 – 2.4	7	225 – 239	3	1.6 – 1.9	6	345 – 354	2
2.5 – 2.9	5	240 – 254	8	2.0 – 2.3	8	355 – 364	2
3.0 – 3.4	13	255 – 269	8	2.4 – 2.7	12	365 – 374	5
3.5 – 3.9	17	270 – 284	21	2.8 – 3.1	13	375 – 384	8
4.0 – 4.4	30	285 – 299	13	3.2 – 3.5	14	385 – 394	7
4.5 – 4.9	17	300 – 314	22	3.6 – 3.9	12	395 – 404	10
5.0 – 5.4	26	315 – 329	21	4.0 – 4.3	21	405 – 414	14
5.5 – 5.9	19	330 – 344	18	4.4 – 4.7	12	415 – 424	15
6.0 – 6.4	13	345 – 359	12	4.8 – 5.1	20	425 – 434	23
6.5 – 6.9	4	360 – 374	7	5.2 – 5.5	10	435 – 444	12
7.0 – 7.4	1	375 – 389	9	5.6 – 5.9	5	445 – 454	22
7.5 – 7.9	0	390 – 404	4	6.0 – 6.3	11	455 – 464	14
8.0 – 8.4	0	405 – 419	3	6.4 – 6.7	7	465 – 474	15
8.5 – 8.9	1	420 – 434	6	6.8 – 7.1	3	475 – 484	8
		435 – 449	1	7.2 – 7.5	1		
$\overline{\Delta n}_{max} = 4.48$ $\sigma = 1.30$ $\alpha_3 = -0.22$ $\alpha_4 = 3.11$		$\overline{V}_o = 318.0$ $\sigma = 48.0$ $\alpha_3 = 0.29$ $\alpha_4 = 2.81$		$\overline{\Delta n}_{max} = 4.12$ $\sigma = 1.44$ $\alpha_3 = -0.02$ $\alpha_4 = 2.38$		$\overline{V}_o = 427.4$ $\sigma = 33.95$ $\alpha_3 = -0.64$ $\alpha_4 = 3.02$	

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TABLE I.– Concluded

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM F8F-1 RECORDS – Concluded

Negative accelerations				Maximum velocity			
Δn_{max} (g)	Frequency	V_o (mph)	Frequency	V_{max} (mph)	Frequency	Δn_{vmax}	Frequency
0.0 – 0.1	4	140 – 162	3	328 – 336	1	(–0.4) – (–0.1)	1
.2 – .3	3	163 – 185	5	337 – 345	0	0. – .3	24
.4 – .5	4	186 – 208	13	346 – 354	1	.4 – .7	4
.6 – .7	7	209 – 231	24	355 – 363	0	.8 – 1.1	22
.8 – .9	8	232 – 254	25	364 – 372	1	1.2 – 1.5	16
1.0 – 1.1	32	255 – 277	36	373 – 381	3	1.6 – 1.9	13
1.2 – 1.3	19	278 – 300	18	382 – 390	1	2.0 – 2.3	15
1.4 – 1.5	21	301 – 323	5	391 – 399	2	2.4 – 2.7	6
1.6 – 1.7	11	324 – 346	6	400 – 408	0	2.8 – 3.1	21
1.8 – 1.9	17	347 – 369	10	409 – 417	9	3.2 – 3.5	11
2.0 – 2.1	13	370 – 392	5	418 – 426	9	3.6 – 3.9	4
2.2 – 2.3	6	393 – 415	4	427 – 435	11	4.0 – 4.3	10
2.4 – 2.5	3	416 – 438	2	436 – 444	5	4.4 – 4.7	6
2.6 – 2.7	2	439 – 461	2	445 – 453	23	4.8 – 5.1	4
2.8 – 2.9	7	462 – 484	2	454 – 462	19	5.2 – 5.5	1
3.0 – 3.1	2			463 – 471	32	5.6 – 5.9	1
3.2 – 3.3	1			472 – 480	24	6.0 – 6.3	1
				481 – 489	6		
				490 – 498	8		
				499 – 507	3		
				508 – 516	1		
				517 – 525	0		
				526 – 534	0		
				535 – 543	0		
				544 – 552	1		
$\overline{\Delta n}_{max}$ = 1.46 σ = 0.65 α_3 = 0.375 α_4 = 3.08		$\overline{V}_o$ = 271.1 σ = 65.41 α_3 = 0.92 α_4 = 3.70		$\overline{V}_{max}$ = 454.0 σ = 30.56 α_3 = –0.95 α_4 = 5.17		$\overline{\Delta n}_{vmax}$ = 2.11 σ = 1.46 α_3 = 0.42 α_4 = 2.35	

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TABLE II

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM F6F-5 RECORDS

Positive accelerations in level flight				Positive accelerations in dive pull-outs			
Δn_{max} (g)	Frequency	V_o (mph)	Frequency	Δn_{max} (g)	Frequency	V_o (mph)	Frequency
1.0 – 1.3	8	135 – 149	1	0.5 – 0.7	1	235 – 249	1
1.4 – 1.7	4	150 – 164	0	.8 – 1.0	0	250 – 264	0
1.8 – 2.1	4	165 – 179	0	1.1 – 1.3	3	265 – 279	1
2.2 – 2.5	9	180 – 194	1	1.4 – 1.6	0	280 – 294	6
2.6 – 2.9	13	195 – 209	1	1.7 – 1.9	3	295 – 309	4
3.0 – 3.3	15	210 – 224	10	2.0 – 2.2	9	310 – 324	7
3.4 – 3.7	13	225 – 239	9	2.3 – 2.5	6	325 – 339	6
3.8 – 4.1	19	240 – 254	21	2.6 – 2.8	7	340 – 354	13
4.2 – 4.5	22	255 – 269	17	2.9 – 3.1	13	355 – 369	5
4.6 – 4.9	13	270 – 284	25	3.2 – 3.4	10	370 – 384	8
5.0 – 5.3	11	285 – 299	6	3.5 – 3.7	13	385 – 399	5
5.4 – 5.7	7	300 – 314	22	3.8 – 4.0	13	400 – 414	15
5.8 – 6.1	8	315 – 329	12	4.1 – 4.3	5	415 – 429	13
6.2 – 6.5	2	330 – 344	7	4.4 – 4.6	6	430 – 444	12
6.6 – 6.9	3	345 – 359	9	4.7 – 4.9	7	445 – 459	8
		360 – 374	3	5.0 – 5.2	5	460 – 474	5
		375 – 389	4	5.3 – 5.5	3	475 – 489	1
		390 – 404	2	5.6 – 5.8	1	490 – 504	2
		405 – 419	0	5.9 – 6.1	2	505 – 419	0
		420 – 434	1	6.2 – 6.4	3	520 – 534	0
				6.5 – 6.7	1	535 – 549	1
				6.8 – 7.0	1		
				7.1 – 7.3	0		
				7.4 – 7.6	0		
				7.7 – 7.9	1		
$\overline{\Delta n} = 3.85$ $\sigma = 1.33$ $\alpha_3 = -0.12$ $\alpha_4 = 2.56$		$\overline{V_o} = 285.43$ $\sigma = 47.39$ $\alpha_3 = 0.30$ $\alpha_4 = 3.10$		$\overline{\Delta n_{max}} = 3.65$ $\sigma = 1.29$ $\alpha_3 = 0.49$ $\alpha_4 = 3.38$		$\overline{V_o} = 387.22$ $\sigma = 57.60$ $\alpha_3 = -0.16$ $\alpha_4 = 2.47$	

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TABLE II.- Concluded

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM F6F-5 RECORDS - Concluded

Negative accelerations				Maximum velocity			
Δn_{max} (g)	Frequency	V_o (mph)	Frequency	V_{max} (mph)	Frequency	Δn_v (g)	Frequency
0.2 - 0.3	1	100 - 114	1	235 - 249	1	(-0.4) - (-0.1)	1
.4 - .5	1	115 - 129	0	250 - 264	1	0 - .3	24
.6 - .7	6	130 - 144	2	265 - 279	1	.4 - .7	15
.8 - .9	14	145 - 159	1	280 - 294	4	.8 - 1.1	12
1.0 - 1.1	25	160 - 174	5	295 - 309	9	1.2 - 1.5	13
1.2 - 1.3	25	175 - 189	5	310 - 324	14	1.6 - 1.9	8
1.4 - 1.5	19	190 - 204	16	325 - 339	5	2.0 - 2.3	15
1.6 - 1.7	5	205 - 219	17	340 - 354	21	2.4 - 2.7	9
1.8 - 1.9	14	220 - 234	22	355 - 369	11	2.8 - 3.1	16
2.0 - 2.1	14	235 - 249	14	370 - 384	11	3.2 - 3.5	10
2.2 - 2.3	9	250 - 264	16	385 - 399	3	3.6 - 3.9	8
2.4 - 2.5	7	265 - 279	4	400 - 414	15	4.0 - 4.3	11
2.6 - 2.7	3	280 - 294	9	415 - 429	10	4.4 - 4.7	3
2.8 - 2.9	2	295 - 309	8	430 - 444	22	4.8 - 5.1	2
3.0 - 3.1	4	310 - 324	12	445 - 459	9	5.2 - 5.5	3
3.2 - 3.3	1	325 - 339	2	460 - 474	7	5.6 - 5.9	0
3.4 - 3.5	0	340 - 354	5	475 - 489	4	6.0 - 6.3	0
3.6 - 3.7	1	355 - 369	4	490 - 504	1	6.4 - 6.7	0
		370 - 384	3	505 - 519	0	6.8 - 7.1	1
		385 - 399	1	520 - 534	1		
		400 - 414	1	535 - 549	1		
		415 - 429	1				
		430 - 444	2				
$\overline{\Delta n}_{max} = 1.55$ $\sigma = 0.64$ $\alpha_3 = 0.74$ $\alpha_4 = 3.15$		$\overline{V}_o = 254.91$ $\sigma = 62.27$ $\alpha_3 = 0.66$ $\alpha_4 = 3.25$		$\overline{V}_{max} = 384.7$ $\sigma = 59.2$ $\alpha_3 = 0.02$ $\alpha_4 = 2.29$		$\overline{\Delta n} = 2.07$ $\sigma = 1.50$ $\alpha_3 = 0.44$ $\alpha_4 = 2.47$	

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TABLE III

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES FROM SB2C-5 RECORDS

Positive acceleration				Negative acceleration			
Δn_{max} (g)	Frequency	V_o (mph)	Frequency	Δn_{max} (g)	Frequency	V_o (mph)	Frequency
0.9 – 1.1	1	260 – 266	2	0.0 – 0.2	1		
1.2 – 1.4	1	267 – 273	0	.3 – .5	3		
1.5 – 1.7	0	274 – 280	3	.6 – .8	8		
1.8 – 2.0	2	281 – 287	0	.9 – 1.1	4		
2.1 – 2.3	2	288 – 294	3	1.2 – 1.4	10	150 – 162	2
2.4 – 2.6	0	295 – 301	4	1.5 – 1.7	14	163 – 175	1
2.7 – 2.9	1	302 – 308	2	1.8 – 2.0	13	176 – 188	1
3.0 – 3.2	4	309 – 315	7	2.1 – 2.3	7	189 – 201	1
3.3 – 3.5	3	316 – 322	6	2.4 – 2.6	4	202 – 214	3
3.6 – 3.8	7	323 – 329	6	2.7 – 2.9	1	215 – 227	1
3.9 – 4.1	6	330 – 336	6			228 – 240	6
4.2 – 4.4	6	337 – 343	5			241 – 253	3
4.5 – 4.7	5	344 – 350	9			254 – 266	7
4.8 – 5.0	11	351 – 357	3			267 – 279	5
5.1 – 5.3	6	358 – 364	4			280 – 292	9
5.4 – 5.6	0	365 – 371	3			293 – 305	3
5.7 – 5.9	2	372 – 378	1			306 – 318	7
6.0 – 6.2	1	379 – 385	1			319 – 331	8
6.3 – 6.5	2					332 – 344	5
6.6 – 6.8	4					345 – 357	2
6.9 – 7.1	0					358 – 370	1
7.2 – 7.4	0						
7.5 – 7.7	0						
7.8 – 8.0	0						
8.1 – 8.3	0						
8.4 – 8.6	1						
$\overline{\Delta n}_{max} = 4.39$ $\sigma = 1.36$ $\alpha_3 = 0.07$ $\alpha_4 = 3.72$		$\overline{V}_o = 327.30$ $\sigma = 27.10$ $\alpha_3 = -0.34$ $\alpha_4 = 2.65$		$\overline{\Delta n}_{max} = 1.53$ $\sigma = 0.60$ $\alpha_3 = -0.26$ $\alpha_4 = 2.49$		$\overline{V}_o = 277.6$ $\sigma = 49.00$ $\alpha_3 = -0.58$ $\alpha_4 = 3.91$	

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TABLE III.— Concluded

FREQUENCY DISTRIBUTIONS AND PARAMETER VALUES

FROM SB2C-5 RECORDS — Concluded

Maximum velocity			
V_{max} (mph)	Fre-quency	Δn_{vmax} (g)	Fre-quency
270 – 279	1	0.0 – 0.2	2
280 – 289	0	.3 – .5	1
290 – 299	2	.6 – .8	2
300 – 309	3	.9 – 1.1	7
310 – 319	1	1.2 – 1.4	4
320 – 329	7	1.5 – 1.7	2
330 – 339	1	1.8 – 2.0	6
340 – 349	11	2.1 – 2.3	1
350 – 359	9	2.4 – 2.6	7
360 – 369	15	2.7 – 2.9	5
370 – 379	8	3.0 – 3.2	14
380 – 389	4	3.3 – 3.5	2
390 – 399	3	3.6 – 3.8	5
		3.9 – 4.1	4
		4.2 – 4.4	0
		4.5 – 4.7	1
		4.8 – 5.0	2
$\overline{V}_{max} = 351.7$ $\sigma = 25.75$ $\alpha_3 = -0.77$ $\alpha_4 = 3.33$		$\overline{\Delta n}_{max} = 2.49$ $\sigma = 1.16$ $\alpha_3 = -0.06$ $\alpha_4 = 2.33$	

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TABLE IV

VARIATION OF MAXIMUM INDICATED AIRSPEED WITH ACCELERATION

INCREMENT FOR THE F8F-1 AIRPLANE

Δn_v	Mid-X	$\Sigma P_{\Delta n_v}$	$P_{\Delta n_v}$	2000 Hours		5000 Hours	
				ΣP_v	V_{max}	ΣP_v	V_{max}
−1							
	−0.5	0.975					
0			0.100	0.0223	503	0.0089	510
	.5	.875					
1			.245	.0091	510	.0036	516
	1.5	.630					
2			.262	.0085	511	.0034	517
	2.5	.368					
3			.198	.0113	508	.0045	515
	3.5	.170					
4			.108	.0206	503	.0083	511
	4.5	.062					
5			.044	.0504	491	.0201	503
	5.5	.0175					
6							

T = 2000 or 5000 hours
$\tau = 31.23$
$k = 7$
$P = P_{\Delta n_v} \quad \Sigma P_v = \frac{\tau}{kT}$
At 2000 hours, $\Sigma P_v = 0.002231/P_{\Delta n_v}$
At 5000 hours, $\Sigma P_v = 0.0008923/P_{\Delta n_v}$

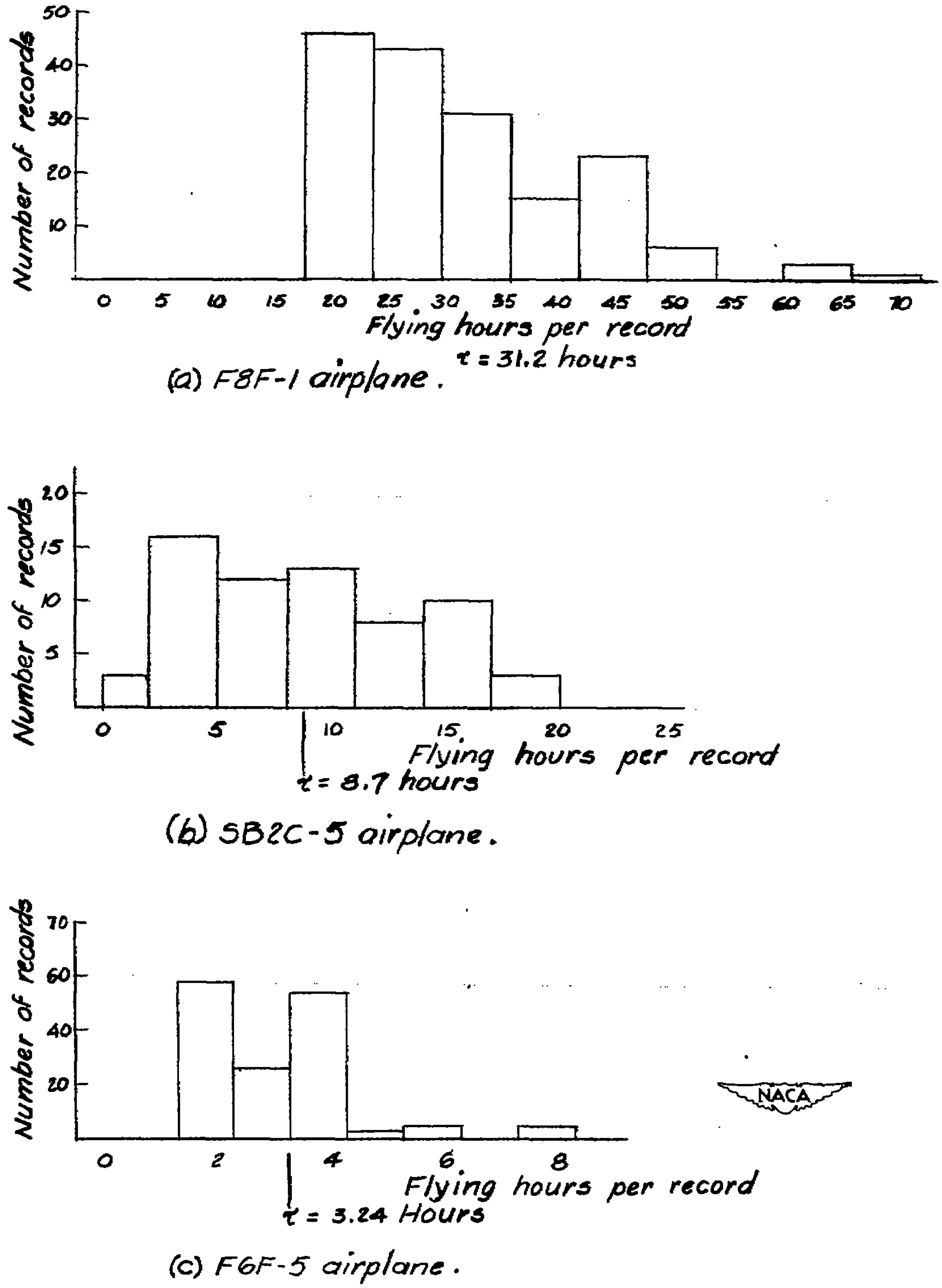

Figure 1.- Distribution of flying hours of records used in the analysis of F8F-1, SB2C-5, and F6F-5 airplanes.

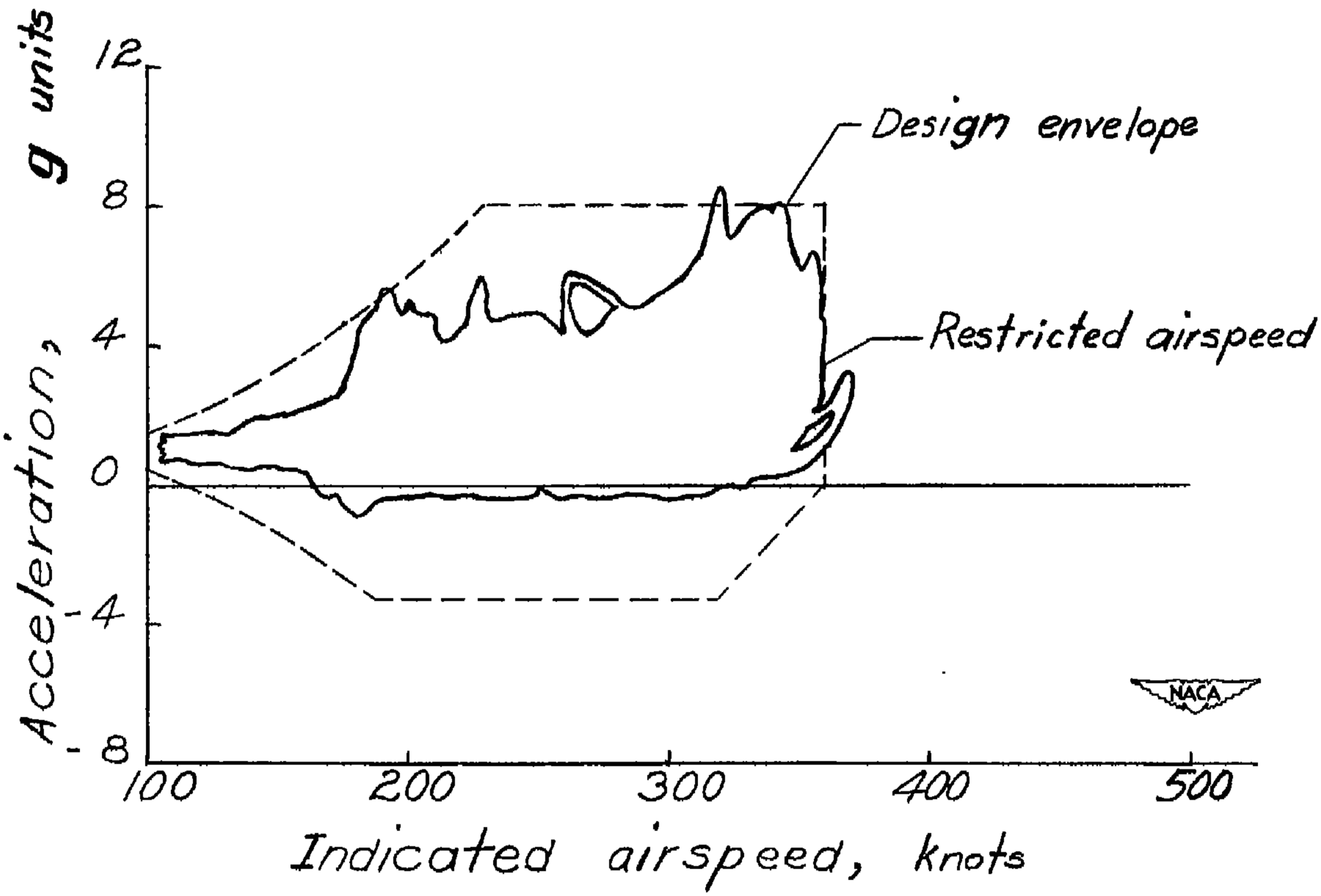

Figure 2.- A 292-hour V-g composite of records obtained with F4U-4 airplanes.

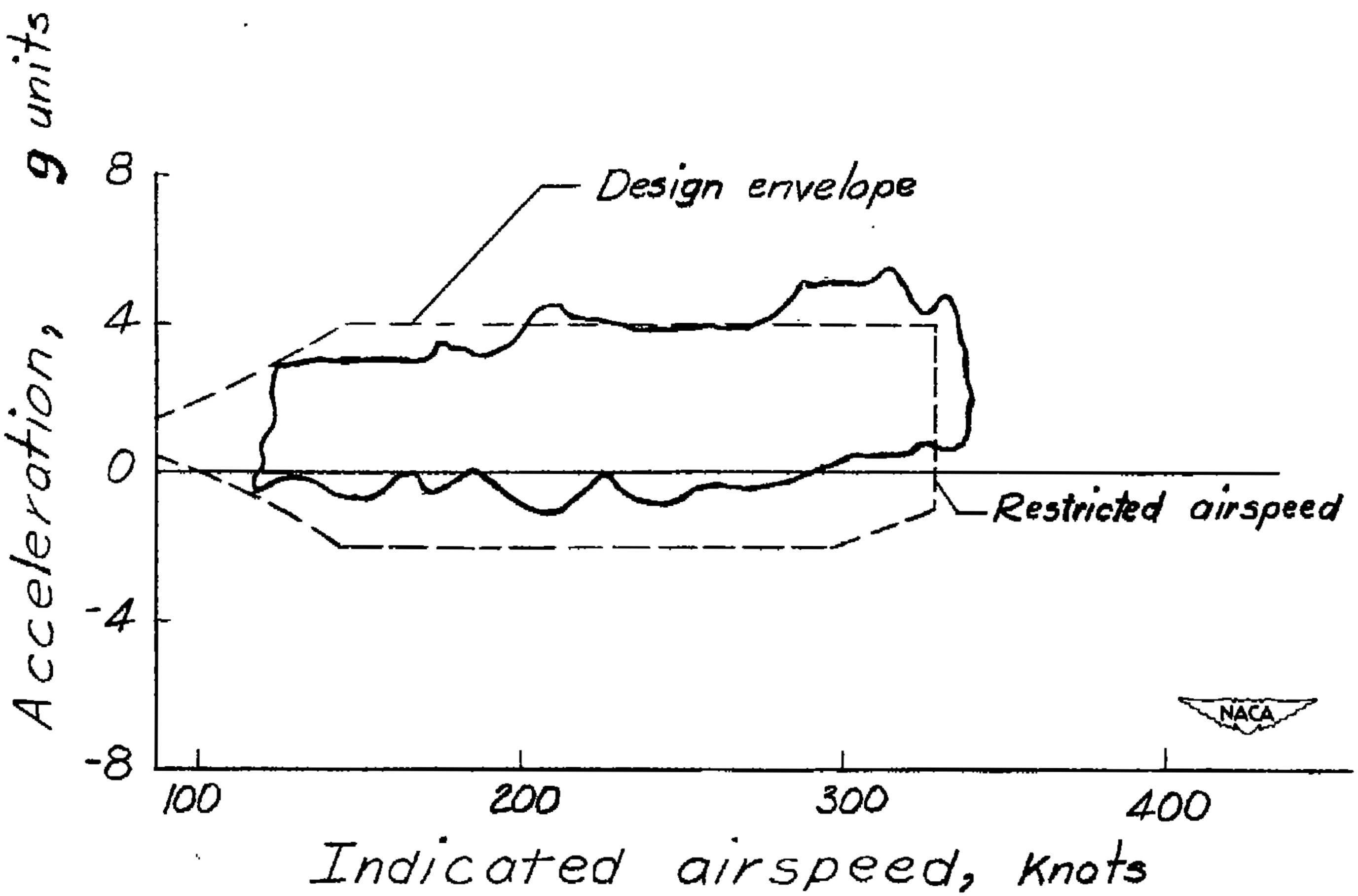

Figure 3.- A 453-hour V-g composite of records obtained with TBM type airplanes.

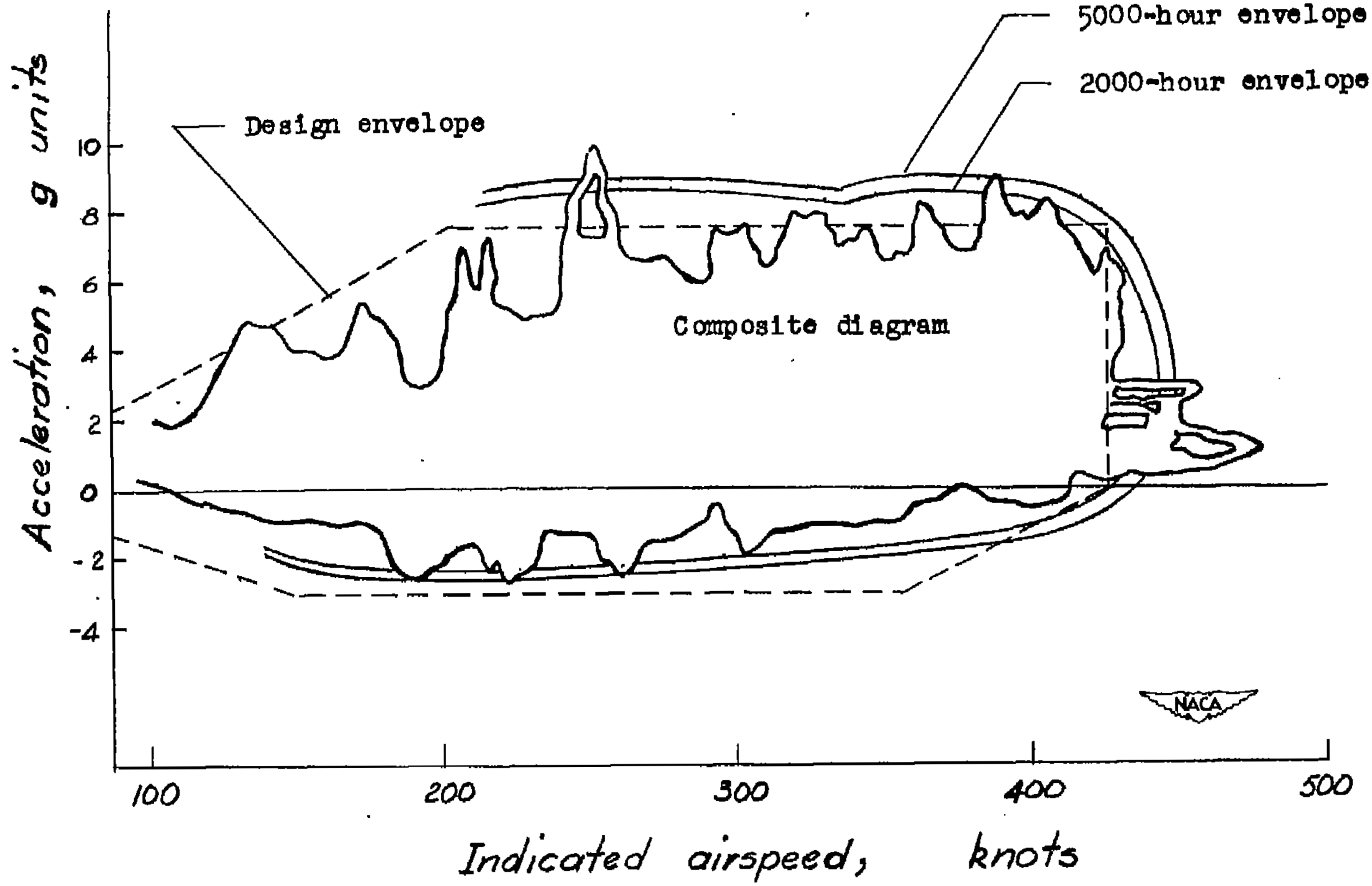

Figure 4.- A comparison of predicted 2000- and 5000-hour envelopes with a 5235-hour V-g composite of records obtained with the F8F-1 airplane.

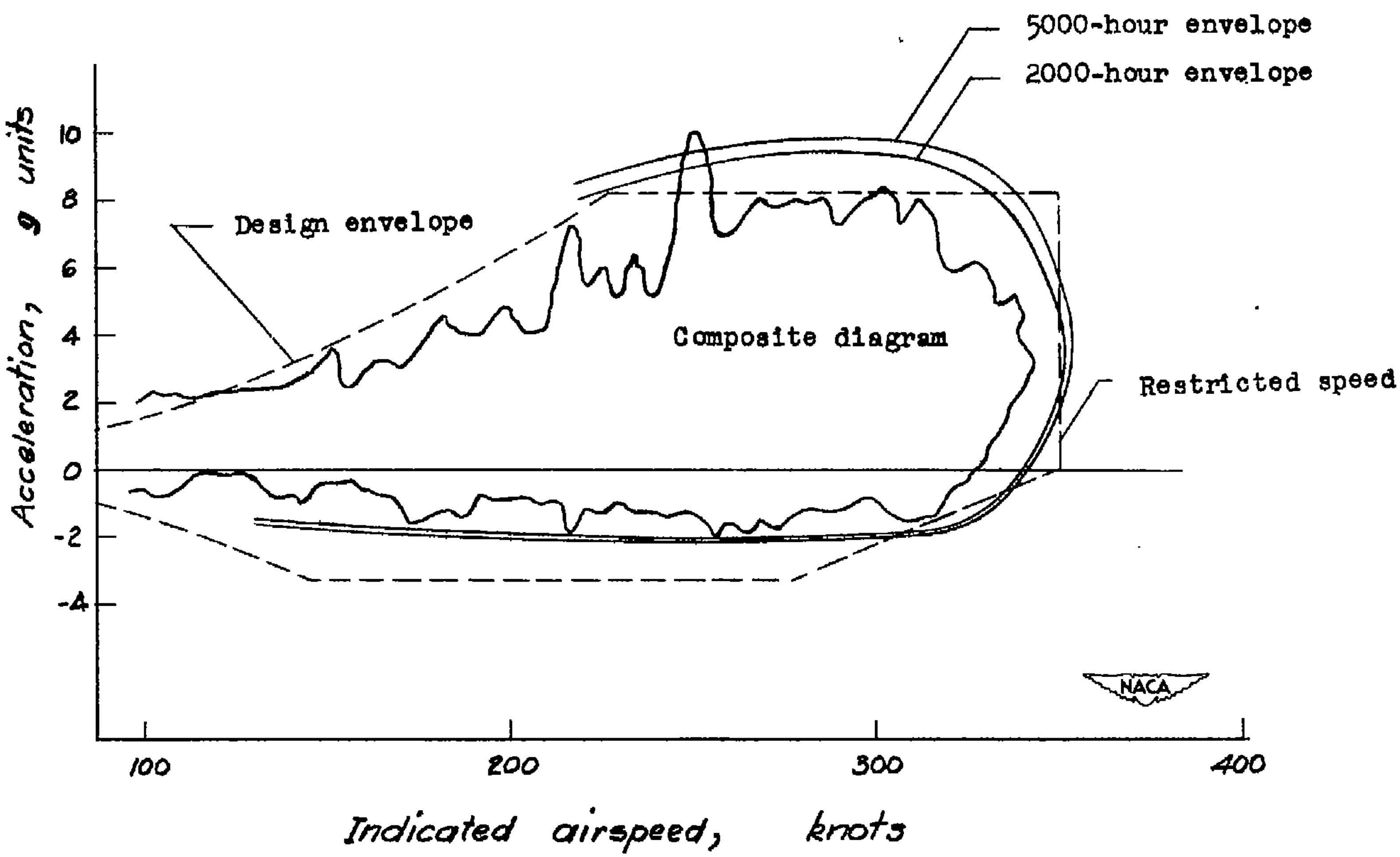

Figure 5.- A comparison of predicted 2000-hour envelopes with a 780-hour V-g composite of records obtained with the SB2C-5 airplane.

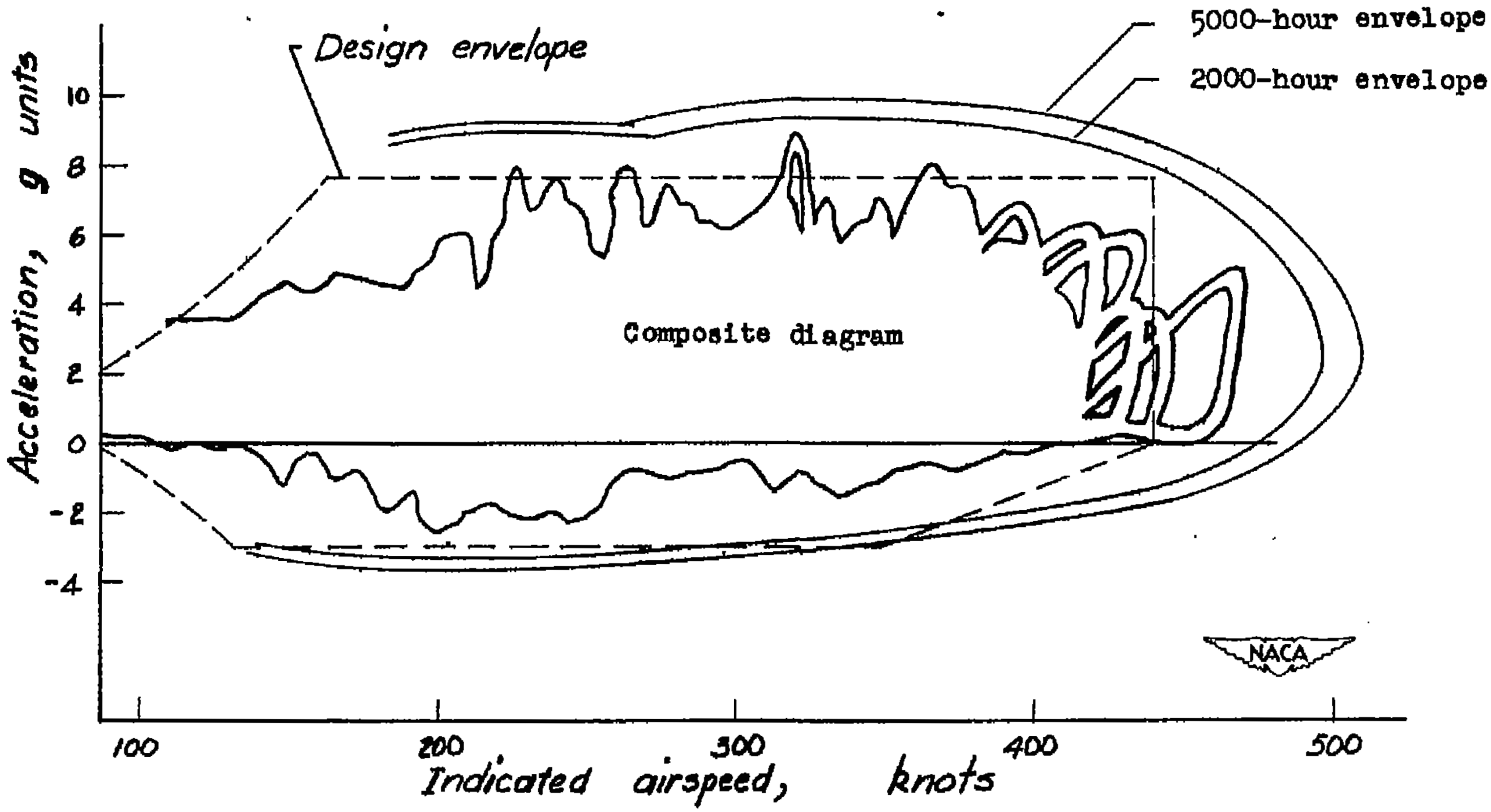

Figure 6.- A comparison of predicted 2000- and 5000-hour envelopes with a 490-hour V-g composite of records obtained with the F6F-5 airplane.

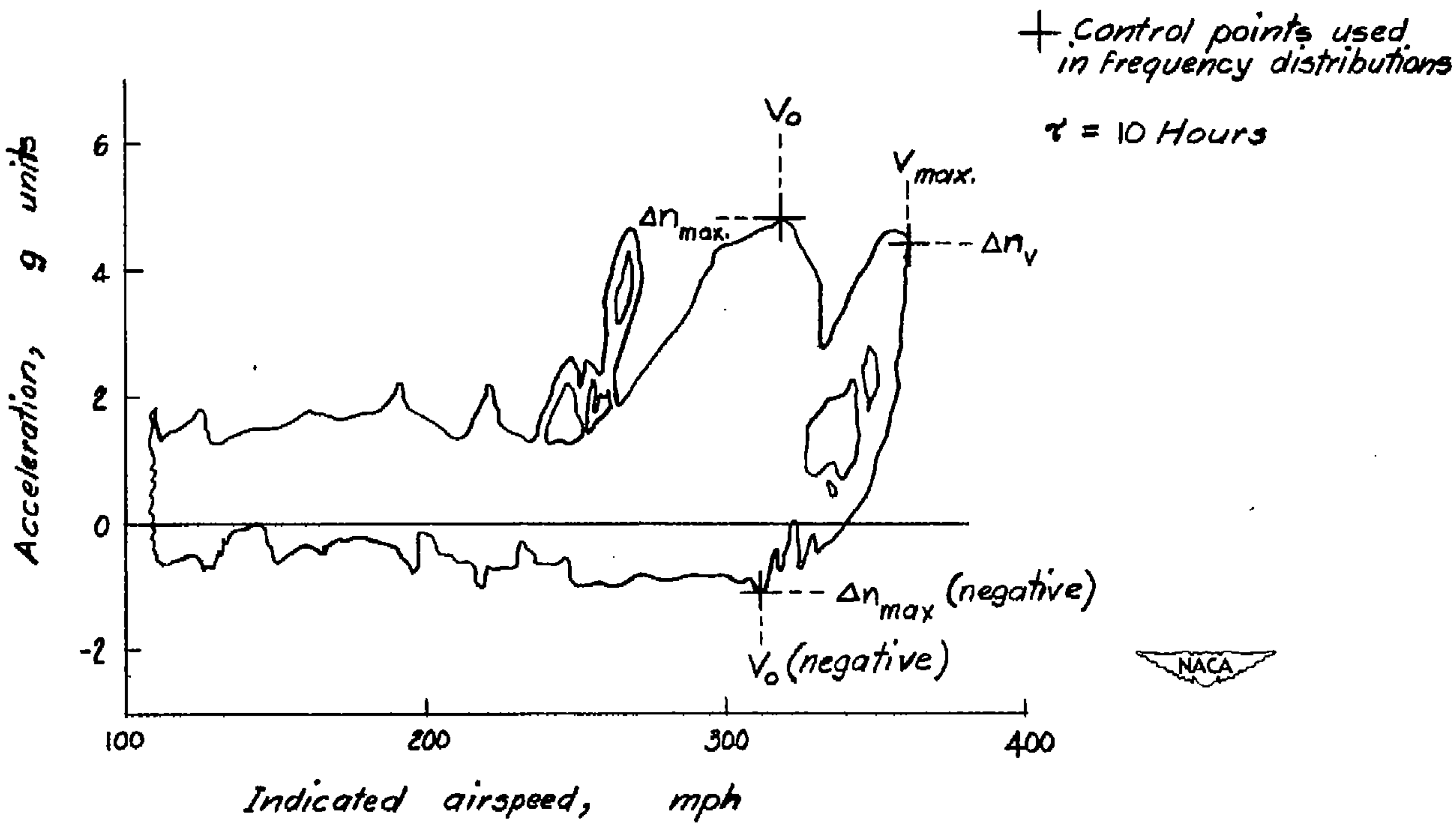

Figure 7.- Sample V-g record from the SB2C-5 airplane.

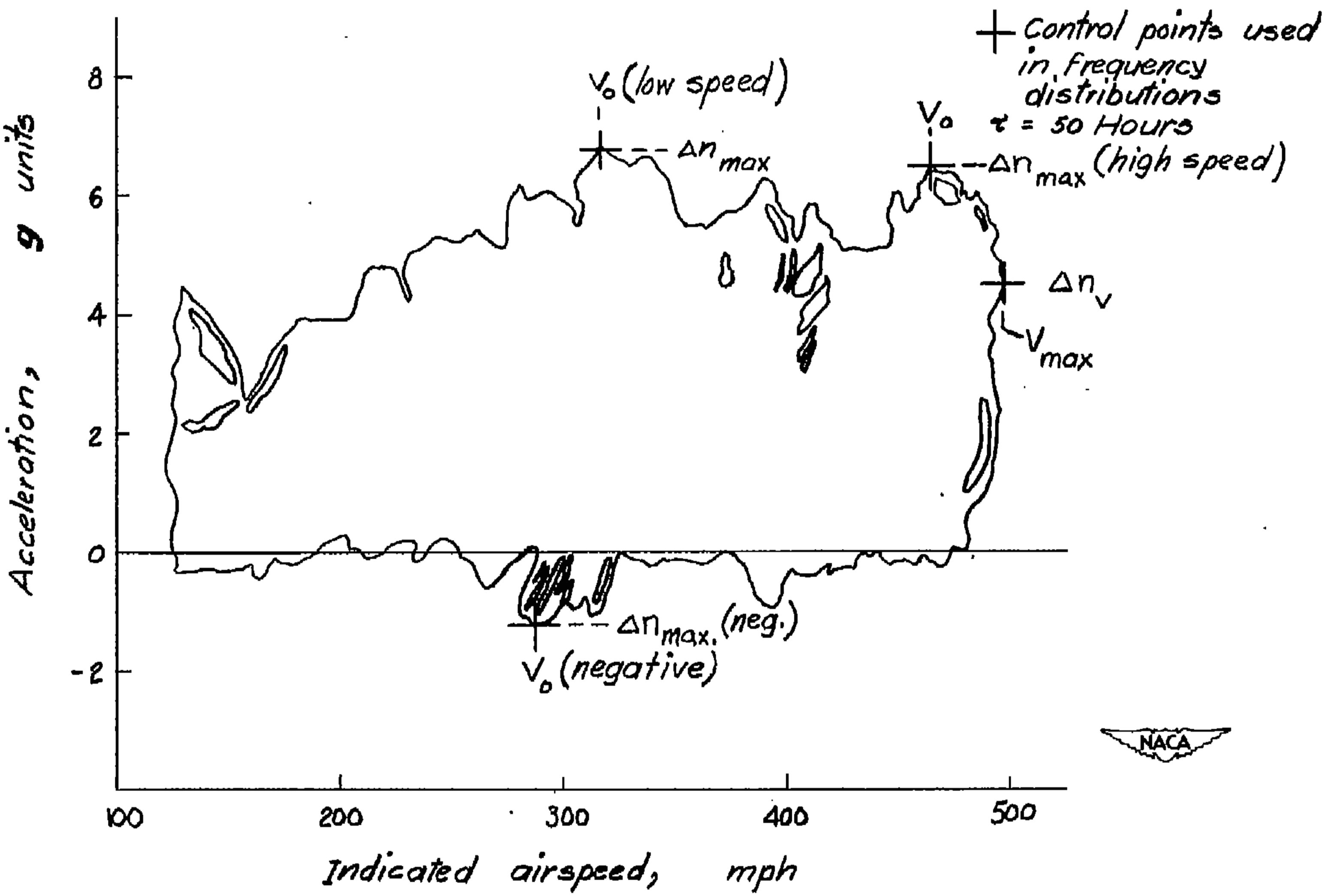

Figure 8.- Sample V-g record from the F8F-1 airplane.

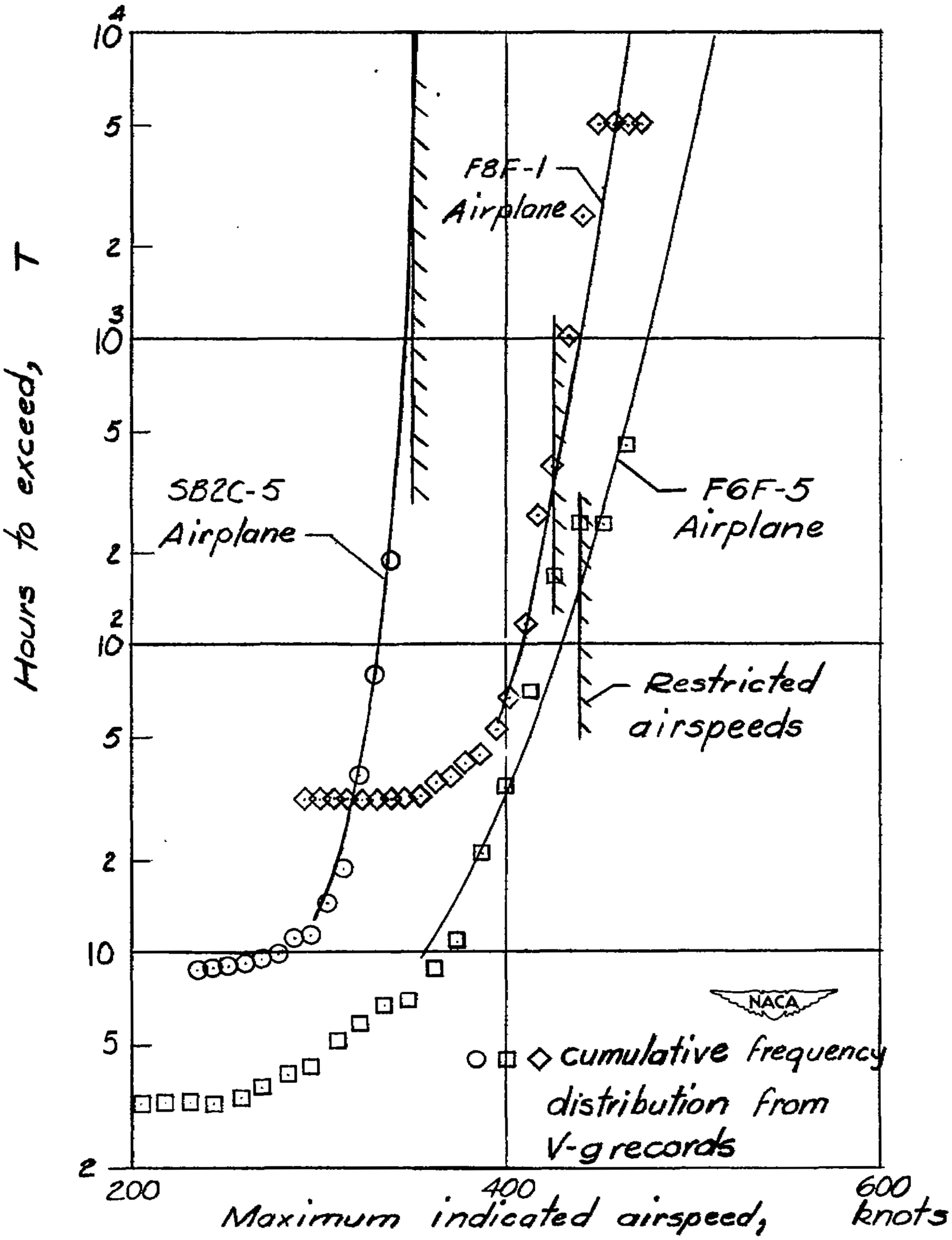

Figure 9.- Average time required to exceed a given value of maximum indicated airspeed.

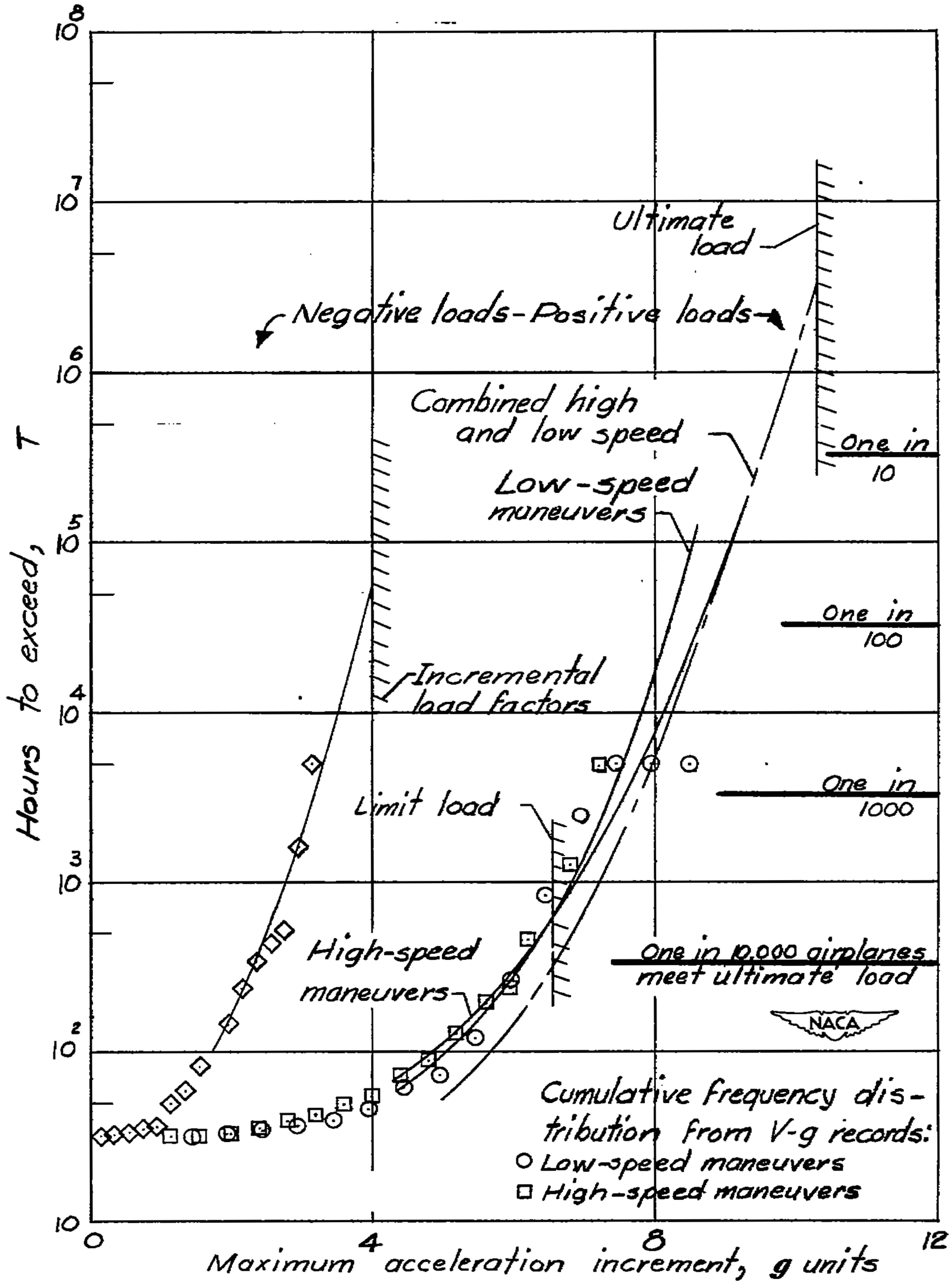

Figure 10.- Average time required to exceed a given value of maximum acceleration increment on a V-g record from the F8F-1 airplane.

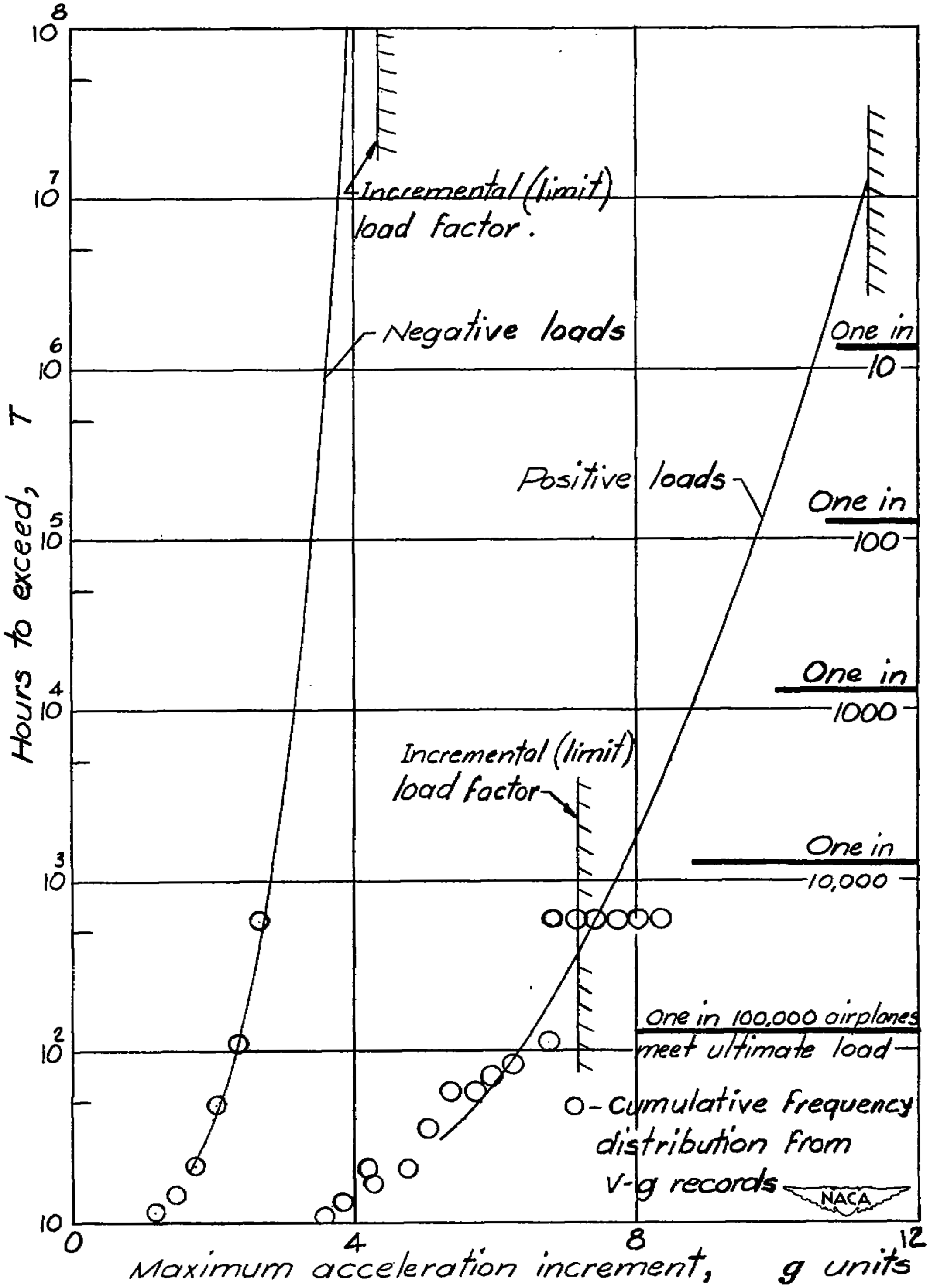

Figure 11.- Average time required to exceed a given value of maximum acceleration increment on a V-g record from the SB2C-5 airplane.

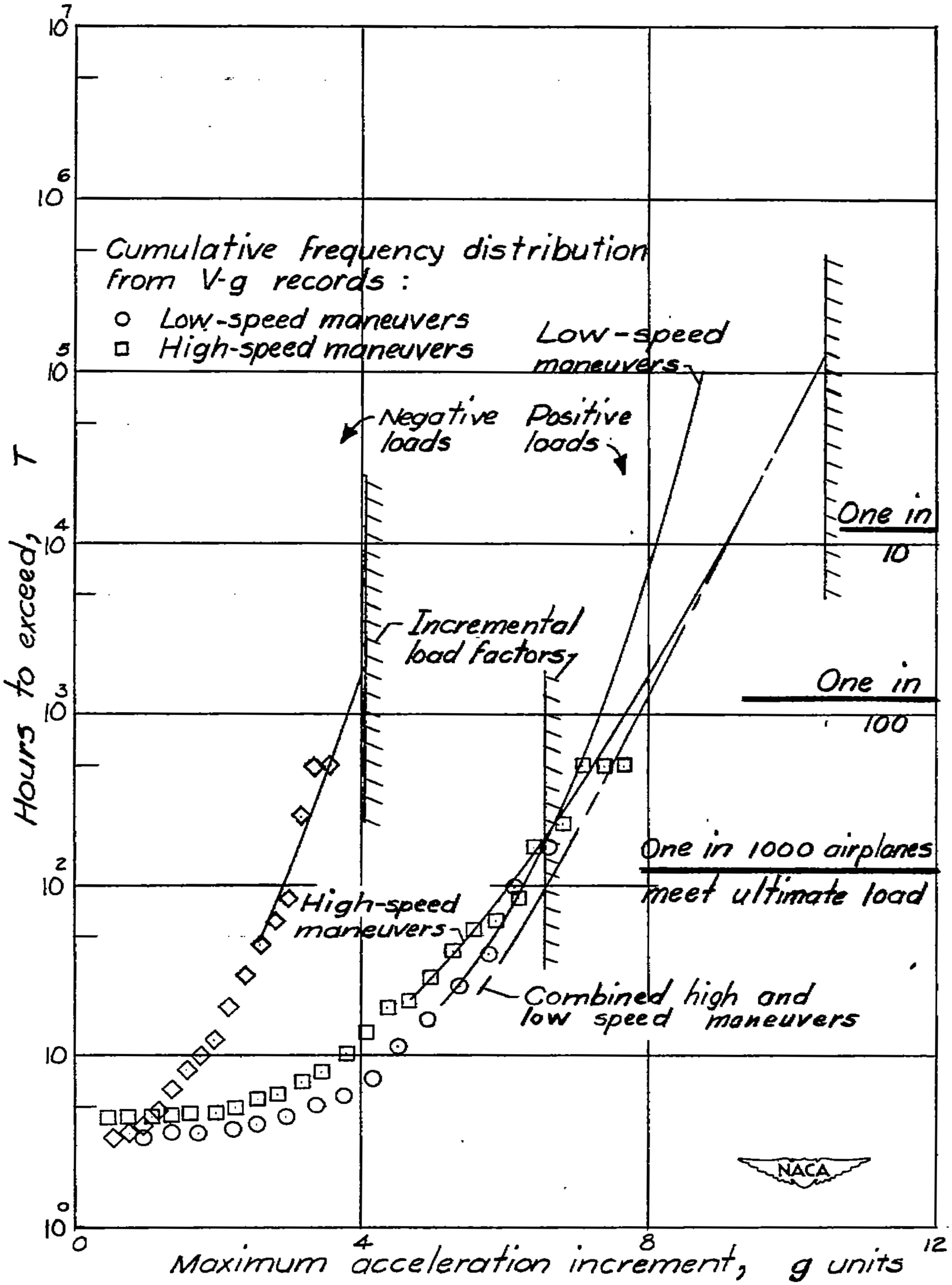

Figure 12.- Average time required to exceed a given value of maximum acceleration increment on a V-g record from the F6F-5 airplane.

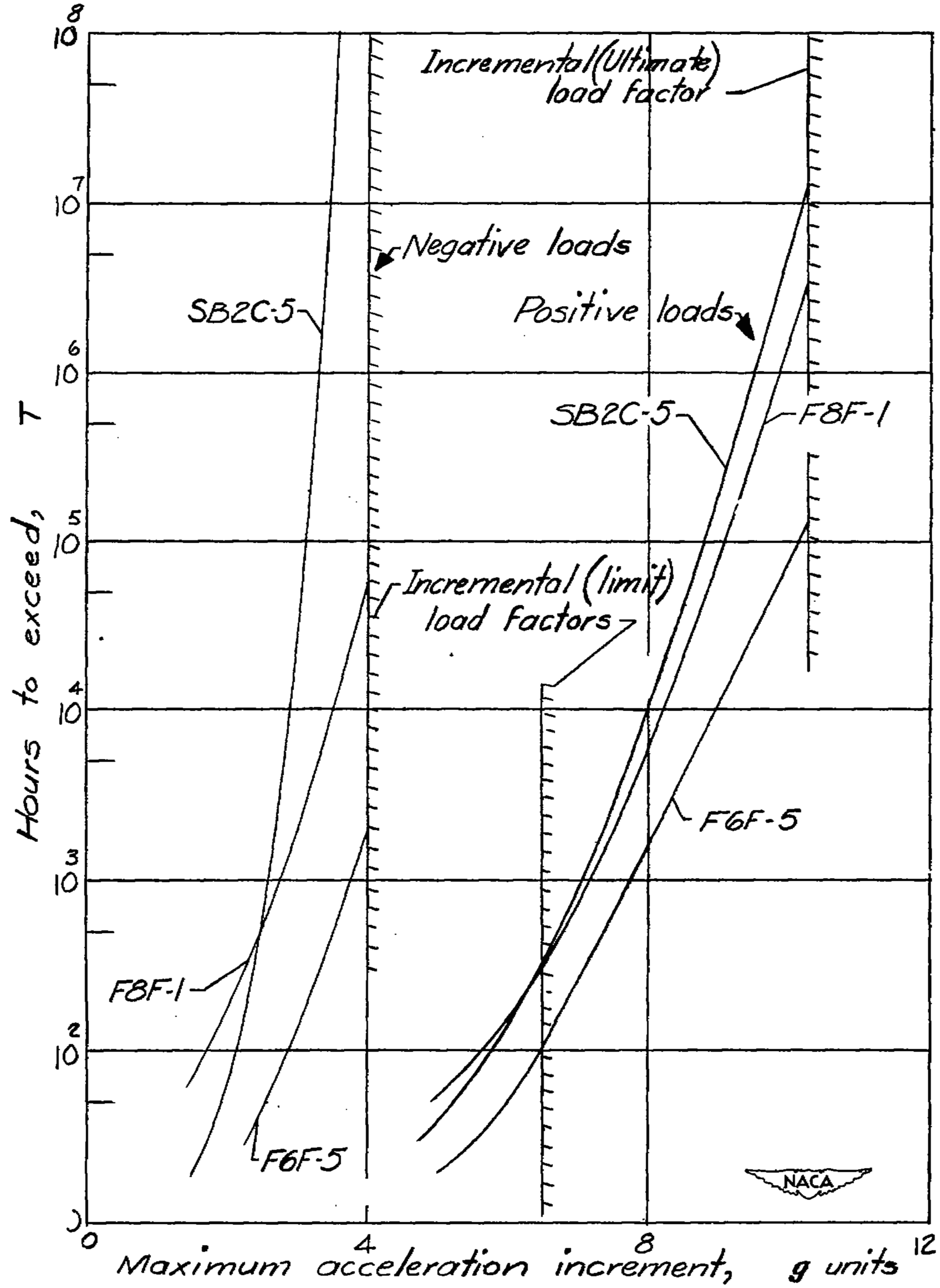

Figure 13.- A comparison of the average time required to exceed given values of maximum acceleration increment on V-g records from the F8F-1, SB2C-5, and F6F-5 airplanes.

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